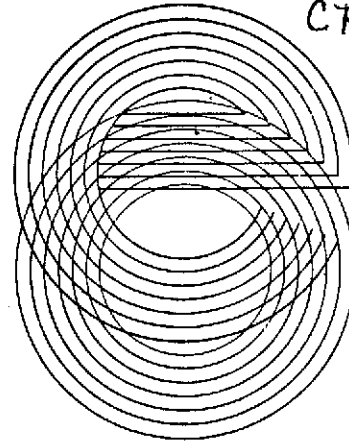


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Eason oil company

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DR. ROBERT J. COLLINS, JR.
President

November 28, 1973

Gentlemen:

This is a Type I Progress Report for the period August
and September 1973.

Experiment Title: An Evaluation of the Suitability
of ERTS Data for the Purposes of
Petroleum Exploration
NASA Proposal No. 173

Principal Investigator: Dr. Robert Collins, GSFC Identifi-
cation No. PR 043

As you know, we have just presented a briefing on the
status of the experiment to the Geology Panel at Goddard
Space Flight Center. The major points covered during that
briefing are contained in this report.

I. CURRENT STATUS OF THE EXPERIMENT

A. Methods of Technical Analysis

We received no RBV imagery. From a total of 49
scenes of MSS imagery received, we interpreted 16 separate
black and white scenes and 7 color composite scenes at a
scale of 1:1,000,000. The remaining 33 scenes are of
limited use because they are peripheral to our test site or
they contain a high percentage of cloud cover. The high
percentage of cloud covered frames underlines the fact that
this is a year of uniquely high rainfall in Oklahoma and
emphasizes the importance of having several years coverage
for geologic interpretation.

We interpreted paper prints, transparencies, and mosaics,
and compiled the results on clear acetate overlays. In
addition, we produced and interpreted 4 mosaics of our site
at a scale of 1:250,000. These include a Spring and a Fall
mosaic both in bands 5 and 7. A variety of optically and
digitally enhanced imagery produced using the 70mm negatives
and positives was also studied at a variety of scales.

E74-10029) AN EVALUATION OF THE
SUITABILITY OF ERTS DATA FOR THE
PURPOSES OF PETROLEUM EXPLORATION
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The MSS imagery was interpreted for inferred lithology; linear features; tonal, textural and circular anomalies; and a variety of other features such as drainage and topography. A complete set of interpretations consisting of overlays showing inferred lithology, linear features and anomalies of various types was done for bands 5 and 7 of every scene used. Selected scenes and interpretation types were done on bands 4 and 6. This has resulted in a total of 110 to 120 individual interpretations to date. At the outset, we attempted to compile all these various interpretations on the same overlay for each frame. We found that there was such a mass of derivable information that even with color coding, the result was a confusing tangle of lines. Consequently, each interpretation was done on a separate overlay. To this point, the studies were done without reference to other available imagery or detailed studies or maps.

From these initial studies, we went in two directions. One approach was to choose small areas for concentrated study. These sites were chosen for two reasons. Study of ERTS imagery located a number of interesting or anomalous sites. We also chose sites on the basis of known structure and/or known hydrocarbon production. This enabled us to focus our attention on small sites from two points of view, namely selection on the basis of ERTS interpretation and on the basis of known oil and gas exploration interest. The other approach was to compile linear, lithologic and tonal anomaly interpretations into regional overlays.

The regional compilations, selected site studies and interpretations of individual frames were analyzed and compared to other existing information. For comparison, we have used maps of surface geology, sub-surface structure, magnetic intensities, oil and gas fields, isopachs, and others. Published reports, side-looking airborne radar (SLAR) provided by the Strategic Air Command (SAC), thermal infrared and high altitude multiband photography supplied by NASA, and conferences with geologists at Eason Oil, the Oklahoma Geological Survey and the Oklahoma School of Geology all provided additional comparative information.

B. Results and Conclusions

Our initial impression was that if one had to make a choice of MSS bands for geological studies, bands 5 and 7 together have the greatest versatility and widest range of easily extractable information. This impression was confirmed by later studies of the uses and applicability of the 4 available bands of ERTS imagery. Bands 5 and 7 are generally of high overall contrast and, in fact, the contrasts are frequently reversed between the two. That is, both mainly show vegetation responses and vegetation is dark on 5 and light on 7.

Bands 5 and 7 may be used for rapid preliminary studies but all bands must be carefully interpreted in order to derive the maximum amount and kinds of geologic information. Each band contains different features which are more easily detectable than on the other bands.

Seasonal differences increase the amount of information available from ERTS. We have found extremes of vegetation growth, that is, maximum vigor and maximum die back, to be most useful. Examples are the strong differences seen in healthy spring vegetation as opposed to dead or dormant plants in a late, dry Fall. So many subtle but important differences appear throughout the year that study of imagery from an entire year or even several years is necessary for optimum results.

We found transparencies at a scale of 1:1,000,000 to be the most convenient format, and a format which allows a near-maximum amount of information to be extracted. Prints at 1:250,000, although somewhat difficult to handle, are the best materials in terms of the amount of information extracted. This scale has several advantages. It matches standard 1° x 2° USGS topographic maps, and it permits careful interpretation and precise location of data points and geologic features. Details which are ambiguous or difficult to define without magnification at 1:1,000,000 are generally resolved at the larger scale. Lineations mapped at 1:1,000,000, contrary to our expectations, generally did not separate into unconnected segments or non-linear features at 1:250,000. In fact, we frequently noted longer, more continuous linears at the larger scale. All the basic interpretations and manipulations can be done at both scales and some information is usually gleaned from each interpretation which is not gleaned from the other.

Summary of ERTS-1 Interpretation

Using ERTS-1 imagery alone, we were able to define the major features of the Anadarko Basin and refined our understanding of many smaller sites within our study area. This type of analysis depended mainly on interpretation of inferred lithology.

Our study defined several regional sets of linears. The sets trending approximately N 40 W and N 80 W in particular are associated with, or control many, of the structural hydrocarbon fields. The N 30 E set is associated with the flanks of a large thin block shown in a middle-Pennsylvanian isopack map of the north flank of the Anadarko Basin. These associations show that the regional linears are either faults or fault-related features which have been active in the past and control the location of many structural hydrocarbon traps and stratigraphic features.

The regional map of anomalies was also compared to other pertinent information. On one overlay we counted 76 anomalous features. We classified these as geomorphic, tonal and "hazy" areas. These "hazy" areas appear on the imagery as if image detail has been smudged or partially erased. They are not atmospheric or photographic effects. They are visible on all bands and the number visible varies with changes in season. They increase in number from east to west. Of 76 anomalies, 59 correlate with producing oil and gas fields, 11 were on known, but non-productive structures, the remainder could not be correlated with known

features. All of the "hazy" anomalies correlated with producing fields or drilled structures. We are in the process of reclassifying and re-analyzing anomalies located on Fall imagery. The same is being done for Spring imagery and will be completed when the remainder of the imagery arrives.

We have studied small sites selected from the anomaly maps, from published reports and at the suggestion of several of our petroleum geologists. In every case we find that focusing our attention in this fashion increases the detail we perceive in an area. Our interpretations frequently differ somewhat from suggested or published analyses. In some instances, we perceive possible new control for features. In a few instances, and notably over the Cement-Chickasha fields, we can add inferred details to known structure but to date have not been able to confidently define the major structural features themselves, which are fairly shallow, strongly folded and faulted structures that have been mapped at the surface. This points up once again the difficulties of analyzing imagery for structures buried under more recent, mildly deformed sediments. In sum, interpretation of ERTS imagery enables us to locate areas for more detailed analysis on ERTS and for aerial photographic and geophysical studies. We have been able to locate most known structures of interest in the ERTS imagery.

It has been apparent throughout the experiment that high altitude multi-band photography and ERTS imagery complement each other and are necessary adjuncts. At the outset, the photography is particularly valuable for understanding tones and small features seen on ERTS imagery. As experience with ERTS grows, there is less need to use photographs for this purpose. As study of ERTS imagery progresses, however, the photography is continually used to precisely locate the many types of interpretable features and to refine interpretation of the features or eliminate them from further consideration. Conversely, there are many features first noted on aerial photographs which are much more subtly expressed on ERTS imagery. Frequently, they are parts of or associated with larger structures or anomalies which can only be defined on ERTS products. Briefly, there is a continual learning cycle in which knowledge garnered from one data source is applied to the other.

We have used some SLAR imagery supplied courtesy of the Strategic Air Command. Some of it is of poor quality, but the portions of good quality imagery have been very useful for confirming linears seen on ERTS imagery, even adding several.

Thermal infrared imagery was collected on the same RB-57 underflight which took multiband photographs of the basin. We find it to be of limited use. It was collected in broad daylight from 60,000 feet and there were some operational problems with the scanner. We have recently had negative enlargements made at a scale approximating 1:250,000. This has increased its value to us. Basically, TIR is an intermediate stage exploration tool, and TIR flown at pre-dawn at lower altitudes and over sites selected from ERTS imagery would be of value at a more detailed level of exploration.

C. Application to Petroleum Exploration and Costs

We have found that the ERTS imagery is a superb tool for reconnaissance exploration of large sedimentary basins or new exploration provinces and quickly focusing attention on anomalous areas of exploration interest. For the first time, small and medium size oil companies can rapidly and effectively analyze exploration provinces as a whole.

More specific types of information derived from ERTS that are useful for petroleum/exploration include:

- A vast quantity of information on linear features--much more than is generally available even on large scale maps.
- Many of the general lithologic relationships that are known to exist in the basin are visible on the imagery.
- A large number of sub-circular anomalies of various types--geomorphic, tonal, etc. The majority of these anomalies identified in the imagery correlated with known structural features and known oil and gas fields.
- Many of the details of the structures controlling hydrocarbon accumulation are visible in the imagery once one's attention is directed to a particular area.
- The overall structure of the basin and many of the major internal structures of the basin are visible on the imagery. In addition, many large scale features previously only postulated to exist on the basis of circumstantial evidence, are clearly visible on the imagery.
- Overall geologic context of the exploration province.

The cost of this equipment is easy to calculate. The cost of obtaining similar or equivalent information by more customary means is difficult to estimate principally because there are a variety of options and hence prices available for obtaining reconnaissance data, and the types of data obtained by the two approaches are not precisely comparable.

However, on the basis of rough estimates, it appears that ERTS could save about 50% of the cost of regional geological exploration.

Despite the problems of comparison involved, it seems, based on preliminary analysis, that the ERTS approach would provide savings primarily reducing the amount of seismic and other types of geophysical surveys needed. Savings produced by incorporating ERTS into an exploration program might amount to half the cost of the survey.

The ERTS approach would also greatly reduce the time required for regional reconnaissance and analysis of the basin as well as conserve technical manpower. It is difficult to assign a dollar figure to either of these types of savings.

II. TASKS TO BE COMPLETED DURING THE FORTHCOMING REPORTING PERIOD

We are nearing the end of our experiment as we originally conceived it, but several tasks remain to be completed.

We need to compile and analyze the interpretations of the Spring imagery and compare these interpretations to those made of the Fall imagery. This must wait on receipt of the remainder of the imagery.

We need to complete the analysis of the regional compilations in terms of what is already known about the geology of the region and the geologic history of the basin.

We need to complete our testing of digital processing methods. In particular, we need to further define the parameters that should be used with each program.

We need to refine the estimates of cost/benefit.

We need to clearly define the role of ERTS interpretation in the exploration cycle and role of enhanced products in the interpretation process.

III. PROBLEMS AND RECOMMENDATION

A major problem we have at present is that imagery requested in April and June has not yet arrived. This is delaying our complete evaluation of the Spring imagery.

Respectfully submitted,

A handwritten signature in dark ink, appearing to read "Robert J. Collins". The signature is fluid and cursive, with the first name "Robert" and last name "Collins" clearly distinguishable.

Robert J. Collins
President, Eason Oil Company